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OFFICE OF  
PREVENTION, PESTICIDES AND  
TOXIC SUBSTANCES

Memorandum

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To: Arthur-Jean Williams, Chief  
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Subject: No Effect Determination for Norflurazon for Pacific Anadromous Salmonids

I reviewed data and other information for norflurazon and its potential effects on Pacific anadromous salmonids and their critical habitat. Norflurazon was included as one of the pesticides in litigation brought by the Washington Toxics Coalition. This pesticide does not seem to warrant action under the Endangered Species Act because I conclude that it will cause 'no effect' on the listed Pacific salmon and steelhead and their critical habitat.

**Background:**

Under section 7 of the Endangered Species Act, the Office of Pesticide Programs (OPP) of the U. S. Environmental Protection Agency (EPA) is required to consult on actions that 'may affect' Federally listed endangered or threatened species or that may adversely modify designated critical habitat. Situations where a pesticide may affect a fish, such as any of the salmonid species listed by the National Marine Fisheries Service (NMFS), include either direct or indirect effects on the fish. Direct effects result from exposure to a pesticide at levels that may cause harm. The following background information applies broadly to endangered species considerations with respect to pesticides. Parts of it, especially those relating to home and garden uses of pesticides are not applicable to norflurazon but I have kept all of the background together even if it does not all apply.

Acute Toxicity - Relevant acute data are derived from standardized toxicity tests with lethality as the primary endpoint. These tests are conducted with what is generally accepted as the most

sensitive life stage of fish, i.e., very young fish from 0.5-5 grams in weight, and with species that are usually among the most sensitive. These tests for pesticide registration include analysis of observable sublethal effects as well. The intent of acute tests is to statistically derive a median effect level; typically the effect is lethality in fish (LC50) or immobility in aquatic invertebrates (EC50). Typically, a standard fish acute test will include concentrations that cause no mortality, and often no observable sublethal effects, as well as concentrations that would cause 100% mortality. By looking at the effects at various test concentrations, a dose-response curve can be derived, and one can statistically predict the effects likely to occur at various pesticide concentrations; a well done test can even be extrapolated, with caution, to concentrations below those tested (or above the test concentrations if the highest concentration did not produce 100% mortality).

OPP typically uses qualitative descriptors to describe different levels of acute toxicity, the most likely kind of effect of modern pesticides (Table 1). These are widely used for comparative purposes, but must be associated with exposure before any conclusions can be drawn with respect to risk. Pesticides that are considered highly toxic or very highly toxic are required to have a label statement indicating that level of toxicity. The FIFRA regulations [40CFR158.490(a)] do not require calculating a specific LC50 or EC50 for pesticides that are practically non-toxic; the LC50 or EC50 would simply be expressed as >100 ppm. When no lethal or sublethal effects are observed at 100 ppm, OPP considers the pesticide will have "no effect" on the species.

Table 1. Qualitative descriptors for categories of fish and aquatic invertebrate toxicity (from Zucker, 1985)

LC50 or EC50	Category description
< 0.1 ppm	Very highly toxic
0.1- 1 ppm	Highly toxic
>1 < 10 ppm	Moderately toxic
> 10 < 100 ppm	Slightly toxic
> 100 ppm	Practically non-toxic

Comparative toxicology has demonstrated that various species of scaled fish generally have equivalent sensitivity, within an order of magnitude, to other species of scaled fish tested under the same conditions. Sappington et al. (2001), Beyers et al. (1994) and Dwyer et al. (1999), among others, have shown that endangered and threatened fish tested to date are similarly sensitive, on an acute basis, to a variety of pesticides and

other chemicals as their non-endangered counterparts.

Chronic Toxicity - OPP evaluates the potential chronic effects of a pesticide on the basis of several types of tests. These tests are often required for registration, but not always. If a pesticide has essentially no acute toxicity at relevant concentrations, or if it degrades very rapidly in water, or if the nature of the use is such that the pesticide will not reach water, then chronic fish tests may not be required [40CFR158.490]. Chronic fish tests primarily evaluate the potential for reproductive effects and effects on the offspring. Other observed sublethal effects are also required to be reported. An abbreviated chronic test, the fish early-life stage test, is usually the first chronic test conducted and will indicate the likelihood of reproductive or chronic effects at relevant concentrations. If such effects are found, then a full fish life-cycle test will be conducted. If the nature of the chemical is such that reproductive effects are expected, the abbreviated test may be skipped in favor of the full life-cycle test. These chronic tests are designed to determine a "no observable effect level" (NOEL) and a "lowest observable effect level" (LOEL). A chronic risk requires not only chronic toxicity, but also chronic exposure, which can result from a chemical being persistent and resident in an environment (e.g., a pond) for a chronic period of time or from repeated applications that transport into any environment such that exposure would be considered "chronic".

As with comparative toxicology efforts relative to sensitivity for acute effects, EPA, in conjunction with the U. S. Geological Survey, has a current effort to assess the comparative toxicology for chronic effects also. Preliminary information indicates, as with the acute data, that endangered and threatened fish are again of similar sensitivity to similar non-endangered species.

Metabolites and Degradates - Information must be reported to OPP regarding any pesticide metabolites or degradates that may pose a toxicological risk or that may persist in the environment [40CFR159.179]. Toxicity and/or persistence test data on such compounds may be required if, during the risk assessment, the nature of the metabolite or degradate and the amount that may occur in the environment raises a concern. If actual data or structure-activity analyses are not available, the requirement for testing is based upon best professional judgement.

Inert Ingredients - OPP does take into account the potential effects of what used to be termed "inert" ingredients, but which are beginning to be referred to as "other ingredients". OPP has classified these ingredients into several categories. A few of these, such as nonylphenol, can no longer be used without including them on the label with a specific statement indicating the potential toxicity. Based upon our internal databases, I can find no product in which nonylphenol is now an ingredient. Many

others, including such ingredients as clay, soybean oil, many polymers, and chlorophyll, have been evaluated through structure-activity analysis or data and determined to be of minimal or no toxicity. There exist also two additional lists, one for inerts with potential toxicity which are considered a testing priority, and one for inerts unlikely to be toxic, but which cannot yet be said to have negligible toxicity. Any new inert ingredients are required to undergo testing unless it can be demonstrated that testing is unnecessary.

The inerts efforts in OPP are oriented only towards toxicity at the present time, rather than risk. It should be noted, however, that very many of the inerts are in exceedingly small amounts in pesticide products. While some surfactants, solvents, and other ingredients may be present in fairly large amounts in various products, many are present only to a minor extent. These include such things as coloring agents, fragrances, and even the printers ink on water soluble bags of pesticides. Some of these could have moderate toxicity, yet still be of no consequence because of the negligible amounts present in a product. If a product contains inert ingredients in sufficient quantity to be of concern, relative to the toxicity of the active ingredient, OPP attempts to evaluate the potential effects of these inerts through data or structure-activity analysis, where necessary.

For a number of major pesticide products, testing has been conducted on the formulated end-use products that are used by the applicator. The results of fish toxicity tests with formulated products can be compared with the results of tests on the same species with the active ingredient only. A comparison of the results should indicate comparable sensitivity, relative to the percentage of active ingredient in the technical versus formulated product, if there is no extra activity due to the combination of inert ingredients. I note that the "comparable" sensitivity must take into account the natural variation in toxicity tests, which is up to 2-fold for the same species in the same laboratory under the same conditions, and which can be somewhat higher between different laboratories, especially when different stocks of test fish are used.

The comparison of formulated product and technical ingredient test results may not provide specific information on the individual inert ingredients, but rather is like a "black box" which sums up the effects of all ingredients. I consider this approach to be more appropriate than testing each individual inert and active ingredient because it incorporates any additivity, antagonism, and synergism effects that may occur and which might not be correctly evaluated from tests on the individual ingredients. I do note, however, that we do not have aquatic data on most formulated products, although we often have testing on one or perhaps two formulations of an active ingredient.

Risk - An analysis of toxicity, whether acute or chronic, lethal

or sublethal, must be combined with an analysis of how much will be in the water, to determine risks to fish. Risk is a combination of exposure and toxicity. Even a very highly toxic chemical will not pose a risk if there is no exposure, or very minimal exposure relative to the toxicity. OPP uses a variety of chemical fate and transport data to develop "estimated environmental concentrations" (EECs) from a suite of established models. The development of aquatic EECs is a tiered process.

The first tier screening model for EECs is with the GENEEC program, developed within OPP, which uses a generic site (in Yazoo, MS) to stand for any site in the U. S. The site choice was intended to yield a maximum exposure, or "worst-case," scenario applicable nationwide, particularly with respect to runoff. The model is based on a 10 hectare watershed that surrounds a one hectare pond, two meters deep. It is assumed that all of the 10 hectare area is treated with the pesticide and that any runoff would drain into the pond. The model also incorporates spray drift, the amount of which is dependent primarily upon the droplet size of the spray. OPP assumes that if this model indicates no concerns when compared with the appropriate toxicity data, then further analysis is not necessary as there would be no effect on the species.

It should be noted that prior to the development of the GENEEC model in 1995, a much more crude approach was used to determining EECs. Older reviews and Reregistration Eligibility Decisions (REDs) may use this approach, but it was excessively conservative and does not provide a sound basis for modern risk assessments. For the purposes of endangered species consultations, we will attempt to revise this old approach with the GENEEC model, where the old screening level raised risk concerns.

When there is a concern with the comparison of toxicity with the EECs identified in the GENEEC model, a more sophisticated PRZM-EXAMS model is run to refine the EECs if a suitable scenario has been developed and validated. The PRZM-EXAMS model was developed with widespread collaboration and review by chemical fate and transport experts, soil scientists, and agronomists throughout academia, government, and industry, where it is in common use. As with the GENEEC model, the basic model remains as a 10 hectare field surrounding and draining into a 1 hectare pond. Crop scenarios have been developed by OPP for specific sites, and the model uses site-specific data on soils, climate (especially precipitation), and the crop or site. Typically, site-scenarios are developed to provide for a worst-case analysis for a particular crop in a particular geographic region. The development of site scenarios is very time consuming; scenarios have not yet been developed for a number of crops and locations. OPP attempts to match the crop(s) under consideration with the most appropriate scenario. For some of the older OPP analyses, a very limited number of scenarios were available.

One area of significant weakness in modeling EECs relates to residential uses, especially by homeowners, but also to an extent by commercial applicators. There are no usage data in OPP that relate to pesticide use by homeowners on a geographic scale that would be appropriate for an assessment of risks to listed species. For example, we may know the maximum application rate for a lawn pesticide, but we do not know the size of the lawns, the proportion of the area in lawns, or the percentage of lawns that may be treated in a given geographic area. There is limited information on soil types, slopes, watering practices, and other aspects that relate to transport and fate of pesticides. We do know that some homeowners will attempt to control pests with chemicals and that others will not control pests at all or will use non-chemical methods. We would expect that in some areas, few homeowners will use pesticides, but in other areas, a high percentage could. As a result, OPP has insufficient information to develop a scenario or address the extent of pesticide use in a residential area.

It is, however, quite necessary to address the potential that home and garden pesticides may have to affect T&E species, even in the absence of reliable data. Therefore, I have developed a hypothetical scenario, by adapting an existing scenario, to address pesticide use on home lawns where it is most likely that residential pesticides will be used outdoors. It is exceedingly important to note that there is no quantitative, scientifically valid support for this modified scenario; rather it is based on my best professional judgement. I do note that the original scenario, based on golf course use, does have a sound technical basis, and the home lawn scenario is effectively the same as the golf course scenario. Three approaches will be used. First, the treatment of fairways, greens, and tees will represent situations where a high proportion of homeowners may use a pesticide. Second, I will use a 10% treatment to represent situations where only some homeowners may use a pesticide. Even if OPP cannot reliably determine the percentage of homeowners using a pesticide in a given area, this will provide two estimates. Third, where the risks from lawn use could exceed our criteria by only a modest amount, I can back-calculate the percentage of land that would need to be treated to exceed our criteria. If a smaller percentage is treated, this would then be below our criteria of concern. The percentage here would be not just of lawns, but of all of the treatable area under consideration; but in urban and highly populated suburban areas, it would be similar to a percentage of lawns. Should reliable data or other information become available, the approach will be altered appropriately.

It is also important to note that pesticides used in urban areas can be expected to transport considerable distances if they should run off on to concrete or asphalt, such as with streets (e.g., TDK Environmental, 1991). This makes any quantitative analysis very difficult to address aquatic exposure from home use. It also indicates that a no-use or no-spray buffer approach

for protection, which we consider quite viable for agricultural areas, may not be particularly useful for urban areas.

Finally, the applicability of the overall EEC scenario, i.e., the 10 hectare watershed draining into a one hectare farm pond, may not be appropriate for a number of T&E species living in rivers or lakes. This scenario is intended to provide a "worst-case" assessment of EECs, but very many T&E fish do not live in ponds, and very many T&E fish do not have all of the habitat surrounding their environment treated with a pesticide. OPP does believe that the EECs from the farm pond model do represent first order streams, such as those in headwaters areas (Effland, et al. 1999). In many agricultural areas, those first order streams may be upstream from pesticide use, but in other areas, or for some non-agricultural uses such as forestry, the first order streams may receive pesticide runoff and drift. However, larger streams and lakes will very likely have lower, often considerably lower, concentrations of pesticides due to more dilution by the receiving waters. In addition, where persistence is a factor, streams will tend to carry pesticides away from where they enter into the streams, and the models do not allow for this. The variables in size of streams, rivers, and lakes, along with flow rates in the lotic waters and seasonal variation, are large enough to preclude the development of applicable models to represent the diversity of T&E species' habitats. We can simply qualitatively note that the farm pond model is expected to overestimate EECs in larger bodies of water.

Indirect Effects - We also attempt to protect listed species from indirect effects of pesticides. We note that there is often not a clear distinction between indirect effects on a listed species and adverse modification of critical habitat (discussed below). By considering indirect effects first, we can provide appropriate protection to listed species even where critical habitat has not been designated. In the case of fish, the indirect concerns are routinely assessed for food and cover.

The primary indirect effect of concern would be for the food source for listed fish. These indirect effects are best represented by potential effects on aquatic invertebrates, although aquatic plants or plankton may be relevant food sources for some fish species. However, it is not necessary to protect individual organisms that serve as food for listed fish. Thus, our goal is to ensure that pesticides will not impair populations of these food sources. In some cases, listed fish may feed on other fish. Because our criteria for protecting the listed fish species is based upon the most sensitive species of fish tested, then by protecting the listed fish species, we are also protecting the species used as prey.

In general, but with some exceptions, pesticides applied in terrestrial environments will not affect the plant material in the water that provides aquatic cover for listed fish. Application rates for herbicides are intended to be efficacious,

but are not intended to be excessive. Because only a portion of the effective application rate of an herbicide applied to land will reach water through runoff or drift, the amount is very likely to be below effect levels for aquatic plants. Some of the applied herbicides will degrade through photolysis, hydrolysis, or other processes. In addition, terrestrial herbicide applications are efficacious in part, due to the fact that the product will tend to stay in contact with the foliage or the roots and/or germinating plant parts, when soil applied. With aquatic exposures resulting from terrestrial applications, the pesticide is not placed in immediate contact with the aquatic plant, but rather reaches the plant indirectly after entering the water and being diluted. Aquatic exposure is likely to be transient in flowing waters. However, because of the exceptions where terrestrially applied herbicides could have effects on aquatic plants, OPP does evaluate the sensitivity of aquatic macrophytes to these herbicides to determine if populations of aquatic macrophytes that would serve as cover for T&E fish would be affected.

For most pesticides applied to terrestrial environments, the effects in water, even lentic water, will be relatively transient. Therefore, it is only with very persistent pesticides that any effects would be expected to last into the year following their application. As a result, and excepting those very persistent pesticides, we would not expect that pesticidal modification of the food and cover aspects of critical habitat would be adverse beyond the year of application. Therefore, if a listed salmon or steelhead is not present during the year of application, there would be no concern. If the listed fish is present during the year of application, the effects on food and cover are considered as indirect effects on the fish, rather than as adverse modification of critical habitat.

Designated Critical Habitat - OPP is also required to consult if a pesticide may adversely modify designated critical habitat. In addition to the indirect effects on the fish, we consider that the use of pesticides on land could have such an effect on the critical habitat of aquatic species in a few circumstances. For example, use of herbicides in riparian areas could affect riparian vegetation, especially woody riparian vegetation, which possibly could be an indirect effect on a listed fish. However, there are very few pesticides that are registered for use on riparian vegetation, and the specific uses that may be of concern have to be analyzed on a pesticide by pesticide basis. In considering the general effects that could occur and that could be a problem for listed salmonids, the primary concern would be for the destruction of vegetation near the stream, particularly vegetation that provides cover or temperature control, or that contributes woody debris to the aquatic environment. Destruction of low growing herbaceous material would be a concern if that destruction resulted in excessive sediment loads getting into the stream, but such increased sediment loads are insignificant from



cultivated fields relative to those resulting from the initial cultivation itself. Increased sediment loads from destruction of vegetation could be a concern in uncultivated areas. Any increased pesticide load as a result of destruction of terrestrial herbaceous vegetation would be considered a direct effect and would be addressed through the modeling of estimated environmental concentrations. Such modeling can and does take into account the presence and nature of riparian vegetation on pesticide transport to a body of water.

Risk Assessment Processes - All of our risk assessment procedures, toxicity test methods, and EEC models have been peer-reviewed by OPP's Science Advisory Panel. The data from toxicity tests and environmental fate and transport studies undergo a stringent review and validation process in accordance with "Standard Evaluation Procedures" published for each type of test. In addition, all test data on toxicity or environmental fate and transport are conducted in accordance with Good Laboratory Practice (GLP) regulations (40 CFR Part 160) at least since the GLPs were promulgated in 1989.

The risk assessment process is described in "Hazard Evaluation Division - Standard Evaluation Procedure - Ecological Risk Assessment" by Urban and Cook (1986) (termed Ecological Risk Assessment SEP below), which has been separately provided to National Marine Fisheries Service staff. Although certain aspects and procedures have been updated throughout the years, the basic process and criteria still apply. In a very brief summary: the toxicity information for various taxonomic groups of species is quantitatively compared with the potential exposure information from the different uses and application rates and methods. A risk quotient of toxicity divided by exposure is developed and compared with criteria of concern. The criteria of concern presented by Urban and Cook (1986) are presented in Table 2.

Table 2. Risk quotient criteria for fish and aquatic invertebrates

Test data	Risk quotient	
Acute LC50	>0.5	Potentially high acute risk
Acute LC50	>0.1	Risk that may be mitigated through restricted use classification
Acute LC50	>0.05	Endangered species may be affected acutely, including sublethal effects

Chronic NOEC	>1	Chronic risk; endangered species may be affected chronically, including reproduction and effects on progeny
Acute invertebrate LC50	>0.5	May be indirect effects on T&E fish through food supply reduction
Aquatic plant acute EC50	>0.5	May be indirect effects on aquatic vegetative cover for T&E fish

The Ecological Risk Assessment SEP (pages 2-6) discusses the quantitative estimates of how the acute toxicity data, in combination with the slope of the dose-response curve, can be used to predict the percentage mortality that would occur at the various risk quotients. The discussion indicates that using a "safety factor" of 10, as applies for restricted use classification, one individual in 30,000,000 exposed to the concentration would be likely to die. Using a "safety factor" of 20, as applies to aquatic T&E species, would exponentially increase the margin of safety. It has been calculated by one pesticide registrant (without sufficient information for OPP to validate that number), that the probability of mortality occurring when the LC50 is 1/20th of the EEC is  $2.39 \times 10^{-9}$ , or less than one individual in ten billion. It should be noted that the discussion (originally part of the 1975 regulations for FIFRA) is based upon slopes of primarily organochlorine pesticides, stated to be 4.5 probits per log cycle at that time. As organochlorine pesticides were phased out, OPP undertook an analysis of more current pesticides based on data reported by Johnson and Finley (1980), and determined that the "typical" slope for aquatic toxicity tests for the "more current" pesticides was 9.95. Because the slopes are based upon logarithmically transformed data, the probability of mortality for a pesticide with a 9.95 slope is again exponentially less than for the originally analyzed slope of 4.5.

The above discussion focuses on mortality from acute toxicity. OPP is concerned about other direct effects as well. For chronic and reproductive effects, our criteria ensures that the EEC is below the no-observed-effect-level, where the "effects" include any observable sublethal effects. Because our EEC values are based upon "worst-case" chemical fate and transport data and a small farm pond scenario, it is rare that a non-target organism would be exposed to such concentrations over a period of time, especially for fish that live in lakes or in streams (best professional judgement). Thus, there is no additional safety factor used for the no-observed-effect-concentration, in contrast to the acute data where a safety factor is warranted because the endpoints are a median probability rather than no effect.

Sublethal Effects - With respect to sublethal effects, Tucker and

Leitzke (1979) did an extensive review of existing ecotoxicological data on pesticides. Among their findings was that sublethal effects as reported in the literature did not occur at concentrations below one-fourth to one-sixth of the lethal concentrations, when taking into account the same percentages or numbers affected, test system, duration, species, and other factors. This was termed the "6x hypothesis". Their review included cholinesterase inhibition, but was largely oriented towards externally observable parameters such as growth, food consumption, behavioral signs of intoxication, avoidance and repellency, and similar parameters. Even reproductive parameters fit into the hypothesis when the duration of the test was considered. This hypothesis supported the use of lethality tests for use in assessing ecotoxicological risk, and the lethality tests are well enough established and understood to provide strong statistical confidence, which can not always be achieved with sublethal effects. By providing an appropriate safety factor, the concentrations found in lethality tests can therefore generally be used to protect from sublethal effects.

In recent years, Moore and Waring (1996) challenged Atlantic salmon with diazinon and observed effects on olfaction as relates to reproductive physiology and behavior. Their work indicated that diazinon could have sublethal effects of concern for salmon reproduction. However, the nature of their test system, direct exposure of olfactory rosettes, could not be quantitatively related to exposures in the natural environment. Subsequently, Scholz et al. (2000) conducted a non-reproductive behavioral study using whole Chinook salmon in a model stream system that mimicked a natural exposure that is far more relevant to ecological risk assessment than the system used by Moore and Waring (1996). The Scholz et al. (2000) data indicate potential effects of diazinon on Chinook salmon behavior at very low levels, with statistically significant effects at nominal diazinon exposures of 1 ppb, with apparent, but non-significant effects at 0.1 ppb.

It would appear that the Scholz et al (2000) work contradicts the 6x hypothesis. The research design, especially the nature and duration of exposure, of the test system used by Scholz et al (2000), along with a lack of dose-response, precludes comparisons with lethal levels in accordance with 6x hypothesis as used by Tucker and Leitzke (1979). Nevertheless, it is known that olfaction is an exquisitely sensitive sense. And this sense may be particularly well developed in salmon, as would be consistent with its use by salmon in homing (Hasler and Scholz, 1983). So the contradiction of the 6x hypothesis is not surprising. As a result of these findings, the 6x hypothesis needs to be re-evaluated with respect to olfaction. At the same time, because of the sensitivity of olfaction and because the 6x hypothesis has generally stood the test of time otherwise, it would be premature to abandon the hypothesis for other sublethal effects until there are additional data.

As you are aware, all of our risk assessment procedures, toxicity test methods, and EEC models have been subject to public comments and have been peer-reviewed by OPP's Science Advisory Panel.

### Effects determination for norflurazon

Given the above considerations, I have evaluated the potential effects of this pesticide on threatened and endangered species. Most of the information used in the assessment below is derived from the Reregistration Eligibility Document (RED) for norflurazon issued June, 1996<sup>1</sup>. Typically, a RED will indicate if there are risks of concern, i.e., exposure that exceeds a "level of concern" (LOC), where there is one level of concern for "high risk", a second as a trigger for "restricted use classification", and a third, more sensitive level of concern for threatened and endangered species. Of course, this RED, like REDs generally, addresses all kinds of species groups, but does not deal with particular species; I have attempted to apply the more general findings of the RED to the specific listed salmonids.

Norflurazon is an herbicide used on cotton, soybeans, peanuts, alfalfa, tree fruits and nuts, berries, asparagus, hops, nursery stock, and a variety of noncrop uses such as rights-of-way, industrial sites, and "wasteland". However, the cotton, soybean, and peanut uses are not allowed in California, Idaho, Washington, and Oregon. In the RED, it is estimated that 1.5-2.6 million pounds ai are used per year, based upon 1991-1994 data. The largest amount of this is on cotton (1-1.5 million pounds), oranges (300,000-600,000 pounds), and grapefruit (50,000-150,000 pounds). However, use on all citrus in California, according to the Department of Pesticide Regulation's (DPR's) pesticide use reporting, is considerably lower with 26,023 lb ai used in 1994, and this does not appear to have changed much with 25,002 lb ai used in 2001. Thus, for uses that account for 1,350,000 to 2,250,000 pounds ai of use, only about 25,000 pounds are used in California.

Table 3. Total California norflurazon use reported to DPR, 1993-2001

year	1993	1994	1995	1996	1997	1998	1999	2000	
pound s ai	164, 451	154, 383	153, 138	196, 142	212, 621	266,8 86	286, 214	257, 851	209,8 07
acres	142, 274	139, 498	133, 585	179, 015	186, 991	214,1 44	217, 178	230, 836	192,1 41

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<sup>1</sup> Reregistration Eligibility Decision - Norflurazon. Office of Pesticides and Toxic Substances, U. S. Environmental Protection Agency, June, 1996.

For 2001, the largest amount of norflurazon used in California was, in order, for almonds, alfalfa, grapes, oranges, rights-of-way, and plums & prunes (table 4). In looking at rates, the major uses generally average 1 lb ai/A or less, except that grapes are at about 1.3 lb ai/A. Only two rights-of-way treatments were reported by acre, and these were 6.7 lb for 11.4 acres. This is too small a sample to consider that it could apply to all rights-of-way treatments.

Table 4. Use of norflurazon reported to DPR for 2001 on various use sites

use site	pounds ai used	
alfalfa	46,013	41,748
almond	46,169	53,087
apple	1,879	1440
apricot	642	1051
asparagus	1662	898
avocado	769	864
blueberry	45	33
cherry	1363	1659
citrus (unspecified)	520	290
cotton	301	315
grape	38,072	49,839
grapefruit	352	280
landscape maintenance	167	NR
lemon	1379	756
nursery-outdoor	19	22
nectarine	4171	4743
orange	21,595	11,429
peach	6857	6416
pear	852	656
pecan	377	305
plums & prunes	11,336	10,843
public health	7	NR
rights-of-way	18,146	NR

tangelo	204	81
tangerine	953	466
uncultivated non-ag	24	8
walnut	5930	4902

Norflurazon is a selective preemergent herbicide used to control germinating annual grasses and broadleaf weeds. It acts by suppressing the production of carotenoids through uptake of pesticide in the root system. According to labels, it does not control emerged weeds, however, it apparently can have some effect because labels specifically say to avoid any contact with crop foliage. It needs to be watered in through rainfall or irrigation; labels call for 0.5-1 inch of water to allow it to penetrate the into the soil. Use on newly planted perennial crops in the spring should be avoided; young plants should be well enough established to not be damaged by application in the fall. The four end-use products include three spray formulations used for all registered sites except cranberries and a 5% granular formulation used on cranberries.

The norflurazon RED stated that the results of aquatic animal tests indicate that norflurazon is slightly to moderately toxic to fish on an acute basis, with LC50 values of 8.1 ppm for rainbow trout and 16.3 ppm for bluegill. Norflurazon was slightly toxic to aquatic invertebrates on an acute basis; no LC50 value was established, but the no-observed-effect-concentration (NOEC) was 15 ppm for *Daphnia magna*.

Based upon fish early-life stage testing, norflurazon had chronic NOECs of 0.77 ppm and 1.1 ppm for rainbow trout and fathead minnows. The lowest-observed-effect-concentrations (LOEC) were 1.5 and 2.1 ppm, respectively. Chronic effects on *Daphnia magna* were at similar levels, with a NOEC of 1.0 ppm and a LOEC of 2.6 ppm.

For estuarine organisms, all acute NOEC levels were above 1.2 ppm, and LC50/EC50 values were from 3.8 ppm to >10 ppm. No chronic data are available on estuarine organisms.

Two tests address aquatic plant toxicity of technical norflurazon. The duckweed (*Lemna gibba*) EC50 was 86 ppb with a NOEC of 42.2 ppb, and the algae (*Kirchneria subcapitata*) EC50 was 13 ppb, with a NOEC of 6.23 ppb.

In general, norflurazon may be described as a persistent and mobile compound. Ground water detections have been reported. The primary route of dissipation appears to be photodegradation, with a half-life of less than 3 days in water and 12-15 days on the soil surface. The major degradates are desmethyl norflurazon, deschloroflurazon, and dimers of norflurazon. Norflurazon is stable to hydrolysis, and is persistent in aerobic soil and

flooded aerobic sediment with half-lives of 130 days and 6-8 months, respectively. The degradates desmethyl norflurazon and carbon dioxide comprised 31-36% and 23-31% of the residues at 365 days, respectively in the aerobic soil study. The anaerobic soil half-life was 8 months. The degradate desmethyl norflurazon appears to be very persistent under both aerobic and anaerobic conditions.

Norflurazon can be generally characterized as mobile to very mobile in soil. The desmethyl degradate has been studied only in high organic content peat soils, where it does not appear to be mobile. Consistent with mobile compounds, it will reach water through either leaching into ground water or as dissolved material in surface runoff. It should not adsorb to soil particles. Bioconcentration is low, with BCF values for whole fish of 16-28x.

Applications according to the label include aerial application for peanuts, cotton, soybeans, and alfalfa; only alfalfa use is permitted in western states. Other labels for perennial crops, such as nursery stock, fruits, and nuts, and rights-of-way uses do not suggest or preclude aerial application. However, the perennial crop/nursery use is all for a directed spray to the soil in established crops with instructions to avoid contact with foliage. It appears highly unlikely that there would be aerial application for these uses. Therefore, the only likely aerial applications in Pacific salmon and steelhead areas would be for alfalfa.

The LC50 for the most sensitive fish species is 8.1 ppm. Based on our standard criterion of concern when the  $RQ > 0.05$ , only EECs in excess of 405 ppb would be of concern. Clearly, with the maximum EEC of 94.2 ppb, there is no direct, acute effect of norflurazon on fish, nor on their aquatic invertebrate food supply. Similarly, no RQs in the RED exceed any chronic concern levels for aquatic animals.

The only other area of possible effect would be indirect effects on aquatic cover for salmon and steelhead. The aquatic macrophyte LC50 is 86 ppb, with a LOEC of 80.7 ppb and a NOEC of 42.2 ppb. The RED (p 61) indicates that "peak" aquatic EECs, based upon GENEEC models, for spray applications range from 21.0 to 70.1 ppb. Granular application at the highest (8 lb ai/A) to cranberries would result in 94.2 ppb EECs. While this appears to be a high RQ, Mastrotta (1996) discusses that because of cranberry culture, it would not be expected to result in significant adverse effects, such as would be required to happen on populations of aquatic plants as cover for listed fish. In addition, the usage indicated in the RED for cranberries is for less than 10% of the crop, and includes only 405 "acre treatments".

"Other crops" treated at the maximum rate of 3.93 lb ai/A would have the second highest EEC of 70.1 ppb. Because of the directed

spray in orchards, the citrus adjustment for banded applications, which yielded an EEC of 35 ppb applies to other comparable perennial fruit and nut crops. On this basis, the "other crop" category would include soybeans, peanuts, asparagus, and alfalfa. However, the soybean and peanut uses are not allowed in the subject area, and the alfalfa application rate is a maximum of 1.97 lb ai/A/yr, which is again equivalent to the citrus. This leaves only the asparagus as an "other crop" where EECs could be 70.1 ppb. Of the pounds of norflurazon applied to asparagus in California in 2001, 492 pounds were applied in Monterey County and 573 pounds were applied in San Joaquin County; other counties had less than 100 pounds or are not in salmon and steelhead areas. Because there is but a single application per year to asparagus and because any norflurazon that did happen to get into salmonid waters would be in flowing streams or rivers, and because the LOEC for Lemna is above the 70.1 ppb EEC (which is from a conservative screening model), use on asparagus would have no effect on cover.

Asparagus in the Northwest is primarily in Washington, which has 20,000+ acres in eastern Washington in salmon areas. Information from the Washington State Department of Agriculture<sup>2</sup> indicates that this use of norflurazon on asparagus is limited to less than 10% of the crop, apparently because of effects on rotational crops. Where it is used, the typical rate will be 2-3 pounds ai/A. Either the rate or the percentage of crop treated is sufficient to reduce the aquatic exposure to below levels of concern for effects on salmonid cover. Oregon has only 1093 acres in Umatilla county and Idaho has a statewide total of 361 acres. Even if norflurazon was used on all acres in these two states, any effects on aquatic cover from use on those acreages would be minimal or none.

Rights-of-way were not modeled in the RED because there is no existing rights-of-way scenario. The rate is the same as for "other crops", i.e., 3.93 lb ai/treated acre, but the "treated acre" would have to be long and narrow, instead of a typically square or rectangular field. There is no current method for estimating an EEC. However, if it is similar to the crop areas with the same rate, it also would be 70.1 ppb. Use in California counties with salmonid ESUs on rights-of-way is less than 1000 pounds per county except Stanislaus (3543 lb), Solano (1220 lb), Los Angeles (1552 lb), and Alameda (1052 lb) counties. There is no information on if and how much norflurazon may be used on rights-of-way in the Pacific Northwest. However, the use should not be so concentrated, because the roadside rights-of-way are not concentrated, as to cause an effect on cover for salmon and steelhead in these states. For reasons comparable to that discussed above for asparagus (single application, flowing waters, below LOEC, conservative model), I conclude that there

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<sup>2</sup> Personal communication, Jim Cowles, Washington State Department of Agriculture, March 18, 2003.



would be no effect on salmon and steelhead cover.

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